Renewable and Sustainable Energy Reviews 28 (2013) 483–493

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A review of islanding detection techniques for renewable distributed generation systems

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ARTICLE INFO

Article history:
Received 23 January 2013
Received in revised form
1 August 2013
Accepted 11 August 2013

Keywords:
Islanding detection
Renewable distributed generation
Distributed generation (DG)

ABSTRACT

Islanding detection of distributed generations (DGs) is one of the most important aspects of interconnecting DGs to the distribution system. Islanding detection techniques can generally be classified as remote methods, which are associated with islanding detection on the utility sides, and local methods, which are associated with islanding detection on the DG side. This paper presents a survey of various islanding detection techniques and their advantages and disadvantages. The paper focused on islanding detection using a conventional and intelligent technique. A summary table that compares and contrasts the existing methods is also presented.

Contents

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1364-0321/$ - see front matter
http://dx.doi.org/10.1016/j.rser.2013.08.025

1. Introduction

Conventional power distribution systems are passive networks, where electrical energy at the distribution level is always supplied to the customer from upstream power resources that are connected to the bulk transmission system. The distributed generation (DG) concept is introduced at the distribution level to exploit the benefits of small local renewable generation. The resources are generally below a couple of MWs and can be wind farms, micro hydro turbines, photovoltaics (PV), and other generators that are supplied with biomass or geothermal energies. The difference between traditional and embedded distribution network systems is illustrated in Fig. 1. In an embedded distribution network system, additional DG resources are supplied near the local load compared with the traditional network system.

The application of multiple DGs in the distribution system is becoming a common practice with the integration of DG resource. This practice is caused by the advantages of DG such as environmental benefits, increased efficiency, avoidance of transmission and distribution (T&D) capacity upgrades, and reduced T&D line losses [1–5]. However, numerous problems should be tackled before the DG units are applied to the networks. These problems include frequency stabilization, voltage stabilization, intermittency of the renewable resources, and power quality issues. The formation of the microgrid (MG), which is cause by the disconnection from the main grid without stopping the energy generation from the DG sources, can also be considered as a drawback of DG [6]. The disconnection of the main source is called islanding, which can be either intentional or unintentional. The purpose of intentional islanding is to construct a power "island" during system disturbances, which are commonly introduced because of the faults. However, the active part of the distribution system should sense the disconnection from the main grid and shut down the distributed generators in countries where island mode operation (MG) is not allowed. Undetected island MG is generally called "unintentional islanding". Fig. 2 shows the formation of a power island because of an upstream fault in the grid system [7,8].

The unintentional islanding of DGs may lead to several problems in terms of power quality, safety, voltage and frequency stability, and interference [3–5,9–11]. The IEEE 1547–2003 standard specifies a maximum delay of 2 s for the detection of the unintentional islanding condition; the IEEE 929–1988 standard requires the disconnection of the DG if islanded [3,4]. Therefore, uncovering effective solutions to resolve this problem is necessary. Research work on unintentional islanding detection is rapidly growing to ensure that the system is operated under the standard requirements. The literature shows several technical publications related to islanding detection from the past twelve years. Most of the ideas that aimed to resolve the problem were proposed after 2007, which indicates the importance of the research subject.

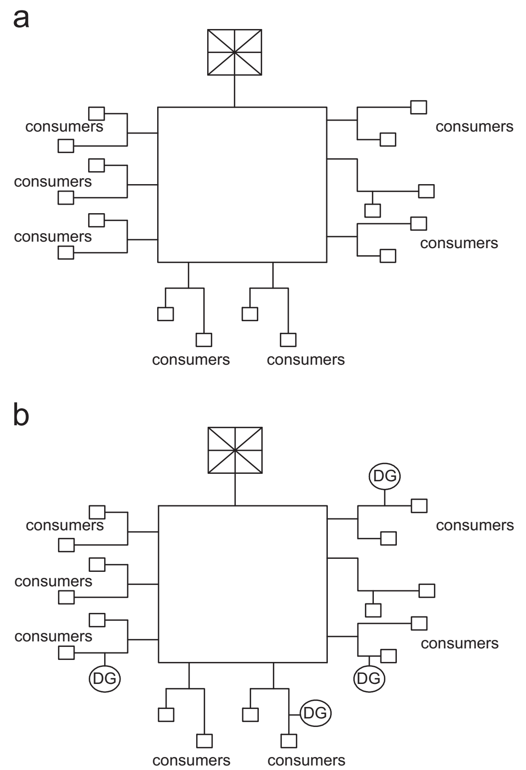

Fig. 1. (a) Traditional distribution system (Traditional Grid System), (b) Generation embedded (Microgrid Networks).

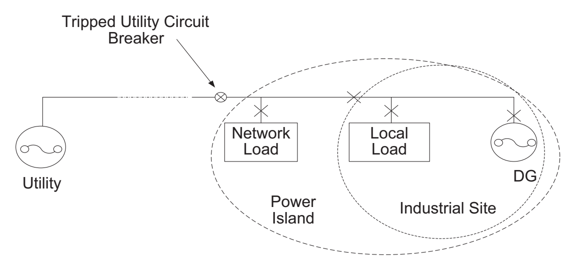

Fig. 2. Illustration of power islanding condition.

2. Islanding detection methods

Various techniques have been developed to detect islanding. These techniques can be broadly classified into central (remote) and local methods as illustrated in Fig. 3. In the following subsections, the details of these methods are explained and evaluated.

2.1. Central (remote) techniques

2.1.1. System state monitoring

System state monitoring is a method for determining system states from a model of the power system network with a reduced number of state measurements. This method is generally regarded as a function of the Distribution Management System (DMS), which is a complementary of supervisory control and data acquisition (SCADA) systems. The method is also used to detect unintentional islanding by monitoring the parameters of the entire distribution system such as voltage and frequency [12]. If the parameter can still be detected from the disconnected area, the occurrence of islanding is detected. This method is highly effective in detecting unintentional islanding if the system is properly instrumented and controlled. However, the cost of implementation is expensive because each inverter requires separate instrumentation and communication equipment. The survey shows that this technique was tested by the PV system. Therefore, other DG types, such as wind turbines and fuel cells, can be explored. The limitation of the high cost of implementation, particularly for small systems, can be addressed using other techniques.

In [6,10], the voltage sensitive devices embedded in the PV-based DG inverter are connected to SCADA system. The loss of mains is detected and notified to the central control system to inform the island mode operation. Real time monitoring of voltage for each generator in the distribution grid can be a cumbersome process with an increased number of DGs connected to the grid. SCADA is also used to monitor auxiliary contact on all circuit breakers between the main source of generation and the DG units [13].